

Heart rate changes in functional capacity evaluations in a workers' compensation population

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Abstract. *Objective:* Functional Capacity Evaluations (FCEs) have been utilized by healthcare professionals for over twenty years to provide an objective assessment of an individual's ability to safely perform functional work activities. Biomechanical observations have been established as a reliable method of determining safe maximal performance levels during dynamic lift testing in FCEs. The purpose of this study is to evaluate heart rate (HR) responses between participants in two performance levels (biomechanical safe-maximal and sub-maximal) and to attempt to establish a minimum threshold for HR changes that should be expected during specific functional testing protocols within FCEs.

Participants: Participants included 500 men and women aged 20 to 85 years whom were injured on the job.

Methods: Variables measured included resting HR, pre-test HR, peak-HR, and resting blood pressure. Percent HR change was calculated for the safe-maximal and sub-maximal performance level groups.

Results: Statistically significant differences ($p = 0.0000000306$) were found in HR change from pre-test to peak HR between performance level groups.

Conclusions: Statistically significant differences were found in percent change in pre-test to peak HR, between the safe-maximal and sub-maximal performance level groups. This study provides the foundation for further research in establishing appropriate minimum expected changes in HR during FCE testing allowing clinicians to make more confident judgments relative to performance level.

Keywords: Occupational health, cardiovascular response, dynamic lift capacity

1. Introduction

A National Academy of Social Insurance study states that in 2007, 55.4 billion dollars were spent for workers' compensation in the United States for medical care and cash benefits [1]. Additionally, 85.4 billion dollars was paid in Social Security Disability Insurance benefits to 6.5 million disabled individuals and their families [2].

As healthcare costs continue to rise and as our society becomes more and more litigious, the importance of Functional Capacity Evaluations (FCEs) continues to increase [3–5]. FCEs, first used in 1972 at Rancho Los Amigos Hospital, are comprehensive, objective examinations to determine an individual's functional status and measure their potential to carry out job related tasks [6–8]. As a result employers, insurance companies, and legal professionals depend heavily on FCEs to make important decisions regarding reimbursement and determining when an employee is able to return to work [3–5].

Additionally, FCEs can be used to determine when an individual's treatment has reached a plateau, if there

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is inconsistency between subjective complaints and objective findings, if a vocational plan needs to be established, and during legal hearings to determine functional capabilities [9]. FCEs can also be used for diagnostic evaluations and determining an individual's readiness to return to work [4]. It should be noted that FCEs are not used to determine an individual's medical condition or disability; rather they are used to verify a person's functional health and physical capabilities [10].

While reliability (inter, intra-rater, and test-retest) and validity for entire FCE protocols are limited, reliability and validity for individual components of FCEs have been established, and are generally good to excellent [3,4,6,8,11,12]. Another major component of FCEs is making an assessment of sincerity of effort during testing [4,13,14]. Currently, determinations of effort are largely based on the subjective judgment of a clinician with varying degrees of experience.

As FCEs are becoming more integral in making determination in workers' compensation cases and other legal matters, there is a need for more objective measures to determine the functional capability of an individual [15]. It has been well established that increases in exertion will cause concomitant increases in heart rate (HR) [16–19]. As a result, HR is an attractive, objective measure to be used as a compliment to biomechanical determinants of effort. In fact, a long held standard for determining an individual's sincerity of effort was whether or not a 10% increase in HR was obtained during a lift designated as the individual's safe-maximal [10]. Recent research, however, has suggested that a 10% change in HR is too lenient [20, 21].

Jay et al. [15], reported a HR response increase of 28% during maximum effort and an 18% increase during sub-maximal effort. From these results, they suggest that a HR response of less than 25% increase be recommended as a measure for sub-maximal effort [20]. Additionally, Lemstra et al., found that when subjects purposefully provided sub maximal effort, subjects' baseline HR increased by 10% or more. In fact, 93% of these subjects had HR increases greater than or equal to 25% when providing submaximal effort [21].

The purpose of this study is to measure the HR responses in workers' compensation individuals to determine if a safe-maximal or sub-maximal performance level was achieved in order to establish guidelines for this population to compliment the clinician's biomechanical observations during dynamic lift testing in functional capacity evaluations. This study will compare HR changes in participants who provide sub-

maximal performance as compared to those who provide safe-maximal performance. Results from this study may establish a minimum expected threshold for HR changes for specific functional testing protocols. The researcher postulates that an increase in HR during functional capacity testing will be consistent with an individual's exertion level. Furthermore, that greater a HR response will be seen for those individuals providing a safe-maximal performance level when compared to those providing a sub-maximal performance level.

2. Methods

Participants consisted of 500 male and female individuals between the ages of 20 and 85 receiving workers' compensation benefits following a work-related injury or illness. All participants were determined by their referring physician to have reached maximum medical improvement.

Exclusion criteria included participants having an unstable medical condition and those taking beta-blockers. Participants who reached a physiological termination point during dynamic lift testing were also excluded from this study (Table 1).

A baseline resting HR and resting blood pressure were measured and recorded prior to administering functional capacity testing. HR was measured using a Polar chest strap monitoring device, and blood pressure was measured manually using a sphygmomanometer.

Participants' HRs were measured and continuously monitored during each of three dynamic lift tests. The dynamic lift tests included a floor to waist level lift, waist to shoulder level lift, and a shoulder to overhead level lift.

Prior to each dynamic lift test, resting HR was recorded with the participants sitting. Peak heart for each participant was recorded during each of the three dynamic lift tests. Between each lift test, participants' HRs were allowed to stabilize to within 10% of their pre-lift test resting HR.

A progressive dynamic lifting protocol with two different steel reinforced wood boxes and a 1-inch steel rod in the center of the box to hold standard plate weights with hand coupling cutouts was utilized. The smaller box measured 14-inches wide, 8-inches deep, 14-inches tall and weighed 15 pounds. The larger box measured 14-inches wide, 14-inches deep, 14-inches tall and weighed 20 pounds.

With each lift test, the load was gradually progressed in 5 to 10 pound increments until a termination point

Table 1
Dynamic lift testing termination criteria

Biomechanical-(safe)	Physiological-(safe)	Psychophysical(sub-maximal)
Load is controlled throughout the range of lift with difficulty Pronounced muscle shakiness of primary lifting and accessory muscle groups Maintains joint stability with difficulty	Working heart rate remains below 85% of age-adjusted maximum Post-exertion blood pressure remains below 250/120 mm Hg with either or both systolic or diastolic pressures after a two-minute rest period Systolic pressure drops less than 20 mm Hg below the resting level after a two-minute rest period Systolic pressure remains above 80 mm Hg Respiration rate remains at or below 45 bpm Oxygen saturation remains above 90%	Voluntary test termination by the patient due to excessive pain complaints or inability to safely handle a heavier load or complete testing
Biomechanical-(unsafe)	Physiological-(unsafe)	
Ballistic movement with initial load movement Inability to safely control the load eccentrically Loss of joint stability	Working heart rate reaches or exceeds 85% of age-adjusted maximum Post-exertion blood pressure reaches or exceeds 250/120 mm Hg with either or both systolic or diastolic pressures after a two-minute rest period Systolic pressure drops more than 20 mm Hg below the resting level after a two-minute rest period Systolic pressure drops below 80 mm Hg Respiration rate exceeds 45 bpm Oxygen saturation drops to 90% or below Evaluator test termination due to the patient's uncooperative or unsafe behaviors	

was reached. Participants were classified as providing either a safe-maximal or sub-maximal performance level for each dynamic lift test. Participants were classified into the safe-maximal performance level group if the evaluator terminated testing because the participants reached an objective biomechanical or physiological termination point (Table 1). Participants were classified into the sub-maximal performance level group if they voluntarily stopped testing prior to reaching an objective biomechanical or physiological termination point or if the evaluator terminated testing due to uncooperative or unsafe lifting behaviors (Table 1).

3. Analysis

A one tailed *t-test* assuming unequal variance was used to determine the percent change in HR response for all three FCE dynamic lifting tests between the two groups. Alpha was set at $p < 0.05$. Descriptive statistics were used to compare gender, age, and resting HR between the two groups.

4. Results

Results from this study display a statistically significant difference in HR percent change in mean pre-

to-peak HR response in the safe-maximal performance level group compared to sub-maximal performance level group for all three lifts: Floor to Waist: 36.73% Safe max 18.28% Sub max ($p = 0.000000306$), Waist to Shoulder: 33.59% Safe max 17.05% Sub max ($p = 0.000000020$) and Shoulder to Overhead: 31.21% Safe max 14.78% Sub max ($p = 0.000000258$).

When divided by gender, statistically significant differences in HR percent change in mean pre-to-peak HR response were also seen in the safe-maximal performance level groups compared to sub-maximal performance level groups.

Men displayed statistical significant differences in HR response on the Waist to Shoulder lift: 33.36% Safe max, 18.16% Sub max ($p = 0.006101515$), and on the Shoulder to Overhead: 31.17% Safe max, 14.44% Sub max ($p = 0.00663093$), However, no statistical significant difference was seen in the Floor to Waist lift: 36.97% Safe max, 26.21% Sub max ($p = 0.0729521241$).

Female participants displayed statistically significant differences in HR response in all three dynamic lifts: Waist to Shoulder lift: 33.36% Safe max, 16.22% Submax ($p = 0.0000070327$), Shoulder to Overhead: 29.21% Safe max, 14.21% Sub max ($p = 0.000898630$), Floor to Waist: 34.09% Safe max, 14.51% Sub max ($p = 0.0000000179$).

When dividing participants by age range, again statistically significant differences in HR response were

Table 2
Dynamic lifts HR responses

	% Change HR		RHR		Peak HR	
	Safe Max	Sub Max	Safe Max	Sub Max	Safe Max	Sub Max
<i>Floor to waist</i>						
Total	35.85%	18.11%	81.88	85.69	109.95	99.85
Male	36.79%*	26.21%*	80.50	82.25	108.70	101.25
Female	34.09%	14.51%	84.47	86.94	112.49	99.06
20–39	41.54%	28.40%	82.50	77.45	115.33	97.82
40–59	34.65%	8.81%	82.48	93.50	109.75	101.83
60+	30.88%	17.53%	77.68	84.67	100.77	99.33
<i>Waist to shoulder</i>						
Total	32.94%	16.84%	81.70	86.44	107.59	100.48
Male	33.36%	18.16%	80.46	82.67	106.23	96.44
Female	32.12%	16.22%	84.07	88.33	110.25	102.75
20–39	37.84%	24.19%	82.00	78.67	112.00	96.91
40–59	31.69%	22.32%	82.43	78.83	107.53	95.00
60+	29.81%	22.39%	77.43	79.50	99.61	96.00
<i>Shoulder to overhead</i>						
Total	30.50%	14.29%	81.61	85.44	105.43	96.25
Male	31.17%	14.44%	80.67	83.33	104.36	94.89
Female	29.21%	14.21%	83.42	86.63	107.53	97.07
20–39	34.63%	18.88%	82.02	80.50	109.19	95.50
40–59	29.55%	9.80%	82.34	92.20	105.48	98.44
60+	27.46%	12.36%	76.68	82.67	97.35	92.67

Alpha was set at $p < 0.05$. *denotes % change not statistically significant.

seen in all three dynamic lifts: Waist to Shoulder lift: Ages 20–39: 37.84% Safe max, 24.19% Sub max ($p = 0.0055524540$); Ages 40–59: 31.69% Safe max 10.62%, Sub max ($p = 0.00000000012$); Age 60+: 29.81% Safe max, 14.44% Sub max ($p = 0.0000906302$); Shoulder to Overhead: Ages 20–39: 34.63% Safe max, 18.88% Sub max ($p = 0.0021327244$); Ages 40–59: 29.55% Safe max, 9.80% Sub max ($p = 0.00000001524$) and Age 60+: 27.28% Safe max, 12.36% Sub max ($p = 0.0066507776$). Floor to Waist lift: Ages 20–39: 41.54% Safe max, 28.40% Sub max ($p = 0.00072316268$); Ages 40–59: 34.65% Safe max, 8.81% Sub max ($p = 0.00000000016$) and Age 60+: 30.88% Safe max, 17.53% Sub max ($p = 0.0112738164$).

Results of descriptive statistics were as follows: Sample was comprised of 314 men and 186 women. Mean age of men was 43 years of age, and 45 for women.

Mean resting HR per lift for Safe max and Sub max level groups showed no statistically significant difference regardless of age or gender (Table 2).

5. Conclusion

Healthcare professionals recognize that clients are unique and therefore, require individualized assess-

ments. These assessments can include but are not limited to medical histories, physical examinations, and diagnostic testing which can generally be used to identify a medical pathology and appropriate treatment interventions. However, the degree to which medical pathologies impact a patient's ability to perform routine functional work activities was more difficult to obtain until the advent of FCEs.

These evaluations are utilized for individuals requiring restricted work levels as well as establishing the level of disability for individuals unable to participate in any work activity [22]. The reliability of FCEs depends on the parameters measured and utilized to evaluate performance. In Pransky et al., reliability was stated to be poor due to various reasons such as: highly variable pain and tolerance levels, difficulty in following instructions or operating equipment, and the individual's control over their effort level to avoid re-injury. In any of the above situations, FCEs are found to be more reliable to detect sub-maximal performance when the maximal effort is obviously not given [23]. Pransky et al., also indicate that it is important to maintain an objective testing environment by using objective findings as the main indicators of performance, such as HR, while only allowing subjective comments, such as pain, to help interpret or understand the final results. This was explained to be more beneficial in maintaining some reliability instead of allowing pain level to determine

outcomes [23]. Fu et al., 2005, demonstrated in their study that with dynamic exercise, males and females have the same HR response regardless of their fitness levels; therefore, the HR responses between genders in this study should not play a significant role in error [24].

In this study, we evaluated participants' HR response during three dynamic lift tests using a one-tailed t- test assuming unequal variance with $p < 0.05$.

Results of this study, displayed a statistical significance difference in HR responses between safe-maximal and sub-maximal performance level groups for all dynamic lift tests. Statistically significant HR response differences were also seen between gender as well as in age range for all three tests. Women displayed statistically significant HR response differences for all three dynamic lift tests. Men displayed statistically significant differences in HR response on all dynamic lifts except Floor to Waist.

No studies to date have compared HR responses of injured individuals in relation to effort levels during FCE testing. Fu and Levine referenced a study done by Sullivan in 1991 that concluded that normal HR response to exercise increases with increasing effort; therefore, it would be safe to theorize that HR would have a greater increase with safe-maximal performance level as compared to a sub-maximal performance level in FCE testing [24]. Further studies evaluating HR response between safe-maximal and sub-maximal performance level groups during FCE testing may provide additional information in order to establish norms for this population. This study provides the foundation for further studies in establishing appropriate minimum expected changes in HR during FCE testing allowing clinicians to make more confident judgments relative to performance level.

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